High speed links
High speed links

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SpaceWire links

“LVDS spacecraft communication network” to ESCC-E-50-12C

AXON’ has developed cables and connectors for SpaceWire links, allowing transfer speeds up to 400 Mb/s.
AXON’ SpaceWire has been approved to ESCC-E-50-12C (SpaceWire cabling) by the French National Space Engineering Centre (CNES).

Signal integrity

AXON’ digital data transmission bus assemblies which meet the MIL-STD-1553 standard are used for military and aeronautic applications, and have also been integrated within the space environment for over 10 years.
In addition to bus harnesses which ensure the connection between on-board devices, SpaceWire links make possible the transfer of up to 400Mb/s while maintaining a wide working margin, thanks to the use of CELLOFLON®, expanded PTFE developed by AXON’.

The ESCC 3902/003 qualified cable and ESCC 3401/029 EPPL2 connectors and accessories manufactured by AXON’ protect the integrity of LVDS signals (Low Voltage Differential Signalling) provided by the devices. The cabling has been optimised in order to reduce the mismatching and crosstalk between lines at the maximum.

A test report validates every SpaceWire link. The electrical performance, which depends on the transmission speed, can be shown with an eye pattern which includes characteristics such as signal jitter. AXON’ can analyse high speed signals up to 10 Gb/s.

Engineering Model or Flight Model designs

AXON’ can offer several designs for Engineering Models (EM) or Flight Models (FM) on request. For custom Lab test harness, AXON’ can offer lightweight design configurations for a more cost effective solution (EMI backshell replaced by conductive potting).

Electrical & environmental characteristics

<table>
<thead>
<tr>
<th>RADIATION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jitter (@ 400 Mb/s)</td>
<td>&lt; 0.35 nS</td>
</tr>
<tr>
<td>Skew (data and strobe lines at 400 Mb/s, length 5 m max.)</td>
<td>&lt; 0.5 nS</td>
</tr>
</tbody>
</table>

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CABLES & HARNESSES FOR SPACE APPLICATIONS - www.axon-cable.com
28AWG SpaceWire cable

CONSTRUCTION
AXON® 28AWG SpaceWire cable qualified to ESCC 3902/003 variant 01 (AXON® part number: P532242) consists of 4 shielded twisted pairs covered by an overall shield and outer jacket, as shown in the specification.

1 - CELLOFLON® expanded PTFE filler
- Diameter: 1.00 mm nom.

2 - 4 x 100 Ω 28AWG BUS Lines
CONDUCTOR AWG 2807
- Stranded silver plated copper alloy 2 µm.
- 7 x 0.127 mm strands.
- Diameter: 0.38 mm nominal.
- Cross section: 0.089 mm² nominal.
- Resistance: 23 Ω/100 m nominal.
DIELECTRIC: CELLOFLON® expanded PTFE.
- Colour: blue / white.
BRAIDED SHIELD
- Material: silver plated copper 2.5 µm.
- Strand diameter: 0.079 mm.
JACKET
- Material: extruded PFA.
- Diameter: 2.37 mm nominal.
- Colour: white.

3 - CELLOFLON® expanded PTFE tape

4 - Braided shield
- Material: silver plated copper 2.5 µm.
- Strand diameter: 0.102 mm.

5 - Outer jacket
- Material: PFA.
- Colour: white.

MAIN CHARACTERISTICS
- Outer diameter: 7.5 mm maximum.
- Weight: 85 g/m maximum.
- Operating temperature: -200 / +180°C.
- Impedance (between wires): 100 Ω (±6 Ω) at 400 MHz.
26AWG SpaceWire cable

CONSTRUCTION

AXON® 26AWG SpaceWire cable qualified to ESCC 3902/003 variant 02 (AXON® part number: P544806) consists of 4 shielded twisted pairs covered by an overall shield and outer jacket, as shown in the specification.

1 - CELLOFLON® expanded PTFE filler
   - Diameter: 1.40 mm nominal.

2 - 4 x 100 Ω 26AWG BUS Lines
   CONDUCTOR AWG 2607
   - Stranded silver plated copper alloy 2 µm.
   - 7 x 0.160 mm strands.
   - Diameter: 0.48 mm nominal.
   - Cross section: 0.141 mm² nominal.
   - Resistance: 14 Ω/100 m nominal.
   DIELECTRIC: CELLOFLON® expanded PTFE.
   - Colour: blue / white.

BINDER
BRAIDED SHIELD
   - Material: silver plated copper 2.5 µm.
   - Strand diameter: 0.079 mm.

JACKET
   - Material: extruded PFA.
   - Diameter: 3.05 mm nominal.
   - Colour: white.

3 - CELLOFLON® expanded PTFE tape

4 - Braided shield
   - Material: silver plated copper 2.5 µm.
   - Strand diameter: 0.102 mm.

5 - Outer jacket
   - Material: PFA.
   - Colour: blue

MAIN CHARACTERISTICS
   - Outer diameter: 9.00 mm maximum.
   - Weight: 115 g/m maximum.
   - Operating temperature: -200 / +180°C.
   - Impedance (between wires): 100 Ω (±6 Ω) at 400 MHz.
Test and measurements

- Eye pattern measurements (up to 10 Gb/s),
  - Jitter measurements,
  - Eye height and width,
  - Q factor,
  - Skew.

- TDR (Time Domain Reflectometry) analysis,
  - Impedance analysis,
  - Skew.

- BER test (Bit Error Rate),
  - PRBS (Pseudo Random Binary Sequence) generation and analysis.

Connection

For either cable size (AWG26 or AWG28), there are two possibilities to connect the link to the PCB:
- Pigtail whose wires are soldered to the PCB.
- Special 9 way CBR connector (each line has the same electrical length to reduce the skew between one another).
IEEE 1394 links

IEEE 1394 A used as spacecraft communication network.

CONSTRUCTION

AXON® IEEE 1394 cable (AXON® part number: P838566) consists of two screened twisted pairs and one unscreened twisted pair as shown in the specification. The cable has an overall shield and jacket.

1 - One 26AWG unscreened pair
   CONDUCTOR AWG 2619
   - Stranded silver plated copper alloy 2 µm.
   - 19 x 0.102 mm strands.
   - Diameter: 0.504 mm nominal.
   - Cross section: 0.15 mm² nominal.
   - Resistance: 13.65 Ω/100 m nominal.
   DIELECTRIC: Extruded PTFE.
   - Colour: black / white.
   - Diameter: 1.00 mm nominal.

2 - Two screened pairs CRP 26AWG - 110 Ω
   CONDUCTOR AWG 2619
   - Stranded silver plated copper alloy 2 µm.
   - 19 x 0.102 mm strands.
   - Diameter: 0.504 mm nominal.
   - Cross section: 0.15 mm² nominal.
   - Resistance: 13.65 Ω/100 m nominal.
   DIELECTRIC: CELLOFLON® (expanded PTFE).
   - Colour: red-green & orange-blue.
   BRAIDED SHIELD
   - Material: silver plated copper 2 µm minimum.
   - Strand diameter: 0.079 mm.
   - Diameter: 2.95 mm nominal.

3 - Drain wire: AWG2619
   CONDUCTOR: same as above.

4 - CELLOFLON® expanded PTFE filler

5 - Two bonded polymide separating tapes

6 - Braided shield
   - Material: silver plated copper 2.5 µm.
   - Strand diameter: 0.127 mm.

7 - Outer jacket
   - Material: wrapped PTFE.
   - Colour: white

MAIN CHARACTERISTICS
- Outer Diameter: 7.15 mm maximum.
- Weight: 84 g/m maximum.
- Operating temperature: -90°C / +200°C.
- Impedance (pair CRP2619 S2): 110 Ω (±6 Ω).
- Voltage rating (E2619): 600 Vac.
IEEE 1394 LINK

WIRING DIAGRAM

Test and measurements

- Eye pattern measurements (up to 10 Gb/s),
  - Jitter measurements,
  - Eye height and width,
  - Q factor,
  - Skew.

- TDR (Time Domain Reflectometry) analysis,
  - Impedance analysis,
  - Skew.

- BER test (Bit Error Rate),
  - PRBS (Pseudo Random Binary Sequence) generation and analysis.

Connection

There are two possibilities to connect the link to the PCB:
- Pigtail whose wires are soldered to the PCB.
- Special 9 way CBR connector (each line has the same electrical length to reduce the skew between one another).
With long experience in space wiring and a mastery of many advanced cabling technologies, AXON® has designed two new solutions to lighten traditional high speed links: The Low Mass SpaceWire and the Ultra Low Mass Coax Link.

### Low Mass solutions

- **Low Mass SpaceWire** has been submitted to an extensive evaluation under ESA supervision, and is currently pending ESA qualification. It is approximately half the mass of existing SpaceWire.
- **Ultra Low Mass Coax Link**, based on AXON’s coaxial cable expertise, is almost 30% lighter still, and is significantly smaller and even more flexible. It is not ESA endorsed for the SpaceWire protocol, but may still be interesting for certain applications.

### Main characteristics

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<th>Low Mass SpaceWire ESCC 3902.004.01</th>
<th>Ultra Low Mass Coax Link with overall shield</th>
<th>Ultra Low Mass Coax Link without overall shield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass (g/m)</td>
<td>80 max.</td>
<td>42 max.</td>
<td>32.5 max.</td>
<td>30 max.</td>
</tr>
<tr>
<td>Overall Ø (mm)</td>
<td>7 max.</td>
<td>6.5 max.</td>
<td>4.5 max.</td>
<td>4.2 max.</td>
</tr>
<tr>
<td>Static bend radius</td>
<td>45</td>
<td>25</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Dynamic bend radius</td>
<td>60</td>
<td>30</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Impedance (Ω)</td>
<td>100 ±6</td>
<td>100 ±6</td>
<td>2x50 ±2</td>
<td>2x50 ±2</td>
</tr>
<tr>
<td>Capacitance (pF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- intra pair</td>
<td>&lt; 50</td>
<td>&lt; 50</td>
<td>&lt; 48</td>
<td>&lt; 48</td>
</tr>
<tr>
<td>- inter pair</td>
<td>&lt; 90</td>
<td>&lt; 90</td>
<td>&lt; 97</td>
<td>&lt; 97</td>
</tr>
<tr>
<td>Resistance DC (Ω/m)</td>
<td>0.23</td>
<td>0.23</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Intra pair skew (ps/m)</td>
<td>&lt; 80</td>
<td>&lt; 50</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>Inter pair skew (ps/m)</td>
<td>&lt; 130</td>
<td>&lt; 100</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>α (dB/m) @1 GHz Cable length (for -6 dB atten.)</td>
<td>-1.5 4.5 m max.*</td>
<td>-1.4 4.6 m max.*</td>
<td>-2.6 2.3 m max.*</td>
<td>-2.6 2.3 m max.*</td>
</tr>
<tr>
<td>Return Loss (dB) up to 2 GHz</td>
<td>-9 max.</td>
<td>-9 max.</td>
<td>-20 max.</td>
<td>-20 max.</td>
</tr>
</tbody>
</table>

* = for a 400 Mb/s data rate (1 GHz)
Low Mass 28AWG SpaceWire

Making use of AXON’s CELLOFLON® expanded PTFE, alveolar a-PTFE dielectrics and AXON’s patented AXALU® silver plated aluminium shields, the new Low Mass SpaceWire cable saves almost half the weight compared to conventional SpaceWire.

CONSTRUCTION

AXON’s Low Mass 28AWG SpaceWire cable according to the ESCC 3902/004.01 requirements (AXON' part number: P551259) consists of 4 shielded twisted pairs covered by an overall shield and outer jacket, as shown in the specification.

1 - CELLOFLON® expanded PTFE filler
- Diameter: 1.35 mm nom.

2 - 4 x 100 Ω 28AWG BUS Lines
CONDUCTOR AWG 2819
- Stranded silver plated copper alloy (2 µm minimum).
- 19 x 0.079 mm strands.
- Diameter: 0.395 mm nominal.
- Cross section: 0.093 mm² nominal.
- Resistance: 23 Ω/100 m nominal.
DIELECTRIC: Alveolar PTFE.
- Colour: blue / white.
INNER BRAIDED SHIELD
- Material: silver plated aluminium (2 µm minimum).
- Strand diameter: 0.079 mm.

3 - Braided shield (in electrical contact with the inner braided shields)
- Material: silver plated aluminium (2 µm minimum).
- Strand diameter: 0.100 mm.

4 - Outer jacket
- Material: Expanded PTFE tape (CELLOFLON®) under a Polymide tape.

MAIN CHARACTERISTICS
- Outer diameter: 6.5 mm maximum.
- Bend radius: 25 mm minimum for fully static applications.
- Weight: 42 g/m maximum.
- Operating temperature: -100 / +150°C.
- Impedance (between wires of a pair): 100 Ω (±6 Ω) at 400 MHz.
- All inner shields are in contact with overall shield.

MAIN ADVANTAGES COMPARED TO THE ESCC3902/003 VARIANT 01
- Smaller bend radius (routing made easier)
- Approximately half the weight
- Reduced intra-pair and inter-pair skews
- Improved resistance to radiations (evaluation performed up to 300 Mrad)
Part list

1. Low Mass SpaceWire cable (P551259)
2. Micro-D plug connector (MDSA209P000B: 9 ways / high phosphorous nickel plated)
3. High phosphorous nickel plated backshell and stainless steel 2-56 UNC-2A fastners
4. Marking sleeve

Cable shield connection: All shields are terminated to the shell of the Micro-D connectors. Alternatively, the shields can also be connected to pin 3 at both ends on request.

Skew inter pair: 0.1 ns/m maximum. / Skew intra pair: 0.05 ns/m maximum.

Depending on the required frequency and data rate, this assembly can be up to 10 meters long without exceeding the 6 dB attenuation limit. This limit is measured at the 5th harmonic of the fundamental equivalent frequency of the LVDS signal (250MHz for 100Mb/s; 500MHz for 200Mb/s or 1GHz for 400Mb/s). The real requirement is to be outside the mask (see above). Please contact us for more details.

Test and measurements

- Eye pattern measurements (up to 10 Gb/s): Jitter measurements, Eye height and width, Q factor and Skew.
- TDR (Time Domain Reflectometry) analysis: Impedance analysis and Skew.
- BER test (Bit Error Rate): PRBS (Pseudo Random Binary Sequence) generation and analysis.
- Crosstalk

Eye pattern measurements diagram at 400 Mb/s for each pair of a lightweight SpaceWire on a 4.5 m assembly. Worst case of amplitude (250 mV peak).
The **Ultra Low Mass Coax Link** based on AXON' coaxial cable expertise, is almost 30% lighter than the already very light Low Mass SpaceWire. This radical solution is significantly smaller and more flexible than the conventional twisted pair approach and exceeds the performance requirements for high speed serial data links compared to twisted pair cables. The coaxial based cable is not recommended for ECSS-E-ST-50-12C SpaceWire links.

It can therefore be an interesting alternative for applications where installation space and mass budgets are extremely limited, or particularly where an alternative protocol to SpaceWire is in use.

**Important:** Potential users of this solution must ensure for themselves that the cable is compatible with their application.

### CONSTRUCTION

AXON’s Ultra Low Mass Coax Link (AXON’ part numbers: P551260 for the version without overall shield and P547585 for the version with) consists of 8 coaxial cables stranded around a filler and outer tape, as shown in the specification.

1. **CELLOFLON® expanded PTFE filler**
   - Diameter: 1.70 mm nominal.

2. **8 x 50 Ω SM50 Coaxial cables**
   - **CONDUCTOR AWG 3407**
     - Stranded silver plated copper alloy (2 µm).
     - 7 x 0.063 mm strands.
     - Diameter: 0.187 mm nominal.
     - Cross section: 0.020 mm² nominal.
     - Resistance: 90.9 Ω/100 m nominal.
   - **DIELECTRIC:** PTFE
     - Colour: white.
   - **BRAIDED SHIELD**
     - Material: silver plated copper (2.5 µm).
     - Strand diameter: 0.063 mm.
   - **JACKET**
     - Material: extruded PFA.
     - Colour: white.

3. **CELLOFLON® expanded PTFE tape** (on P551260 only)

4. **Braided shield** (on P547585 only)

5. **Polyimide tape** (single layer on P551260, double layer on P547585)

### MAIN CHARACTERISTICS

- Outer diameter: 4.20 mm maximum (4.50 mm with overshield).
- Bend radius: 6 mm minimum for fully static applications.
- Weight: 30 g/m maximum (32.5 g/m with overshield).
- Operating temperature: -100 / +150°C.
- Impedance (between wires of a pair): 8x50 Ω at 400 MHz.

### MAIN ADVANTAGES COMPARED TO THE ESCC 3902/003 VARIANT 01

- Smaller bend radius (routing made easier)
- More than half weight saving
- Reduced intra-pair and inter-pair skews
- Improved resistance to radiations

Note: One drawback is a shorter maximum length due to higher attenuation.

Ultra Low Mass Coax Links can be terminated with 9 way Micro-D connectors (such as are employed on SpaceWire and Low Mass SpaceWire links) or ultra miniature 15 way Nano-D connectors, suitable for applications where the connector interface area is extremely limited.
**Part list**

1. Ultra Low Mass Coax cable (P551260 or P547585)
2. Micro-D plug connector (MDSA209P000B: 9 ways / high phosphorous nickel plated)
3. High phosphorous nickel plated backshell and stainless steel 2-56 UNC-2A fastners
4. Marking sleeves

**Cable shield connection**: All coaxial shields are terminated to the shell of both connectors.

**Skew inter pair**: 0.1 ns/m maximum. / **Skew intra pair**: 0.02 ns/m maximum.

Depending on the required frequency and data rate, this assembly can be up to 4 meters long without exceeding the 6 dB attenuation limit. This limit is measured at the 5th harmonic of the fundamental equivalent frequency of the LVDS signal (250MHz for 100Mb/s; 500MHz for 200Mb/s or 1GHz for 400Mb/s). The real requirement is to be outside the mask (see above). Please contact us for more details.

**Test and measurements**

- **Eye pattern measurements (up to 10 Gb/s)**: Jitter measurements, Eye height and width, Q factor and Skew.
- **TDR (Time Domain Reflectometry) analysis**: Impedance analysis and Skew.
- **BER test (Bit Error Rate)**: PRBS (Pseudo Random Binary Sequence) generation and analysis.
- **Crosstalk**
Part list

1 - Ultra Low Mass Coax cable (P551260 or P547585)
2 - Nano-D plug connector (ND2A215P000B: 15 ways / nickel plated)
3 - Nickel plated backshell and stainless steel 0-80 UNF fasteners
4 - Marking sleeves

**Cable shield connection:** All coaxial shields are terminated to the shell of both connectors.

**Skew inter pair:** 0.1 ns/m maximum. / **Skew intra pair:** 0.02 ns/m maximum.

Depending on the required frequency and data rate, this assembly can be up to 4 meters long without exceeding the 6 dB attenuation limit. Please contact us for more details.

**Test and measurements**

- **Eye pattern measurements (up to 10 Gb/s):** Jitter measurements, Eye height and width, Q factor and Skew.
- **TDR (Time Domain Reflectometry) analysis:** Impedance analysis and Skew.
- **BER test (Bit Error Rate):** PRBS (Pseudo Random Binary Sequence) generation and analysis.
- **Crosstalk**
High data rate links
for faster data transmission

AXON’ proposes AXOMACH®, a range of high data rate links composed of low loss microwave coaxial cables and different connector types: AXOMACH® Micro-D based cable mount, panel mount, SMD or saver connectors as well as SMA panel mount connectors.

Aimed, for example, at the interconnection of high definition imagery sensors in satellites these links present the following main advantages:

- Transmission of high data rates: 10 Gb/s up to 40 Gb/s,
- Signal integrity: skew < 10 ps per mated pair,
- Low mismatching: differential characteristic impedance 100 Ω (±10 Ω),
- Low crosstalk < -35 dB at 10 GHz,
- Improved EMC behavior: shielding effectiveness for 1 m link < -60 dB up to 10 GHz,
- Space saving: about half the width of a standard SMA connector for the same number of contacts.

Construction

A procurement specification is available on request. This document following ESCC format details the rating, physical and electrical characteristics, test & inspection data for AXON’ space grade high data rate AXOMACH® series connectors and links.

On the following pages each component of this high data rate link will be described in detail.
Microwave coaxial cable

**AXOWAVE 2.4**

AXON part number: P840563

Cable terminated with Micro-D based cable mount connectors, PCB connectors, SMA connectors.

**CONDUCTOR**
- Silver plated copper (Ag 2µm).
- AWG 2401.
- Area 0.205 mm².
- Resistance: 10 Ω/100 m.

**DIELECTRIC**
- Extruded CELLOFLON® (expanded PTFE).
- Colour: natural.
- Nominal diameter: 1.51 mm.

**SHIELDING**
Silver plated copper tape.

**SEPARATING TAPE**
Polyimide.

**SHIELDING**
Silver plated copper braid (Ag 2µm), nominal diameter over braid: 1.92 mm.

**JACKET**
- PFA.
- Colour: blue.

**MAIN CHARACTERISTICS**
- Nominal outer diameter: 2.40 mm.
- Approximate weight: 16 g/m.
- Nominal impedance: 50 Ω.
- Nominal capacitance: 87 pF/m.
- Temperature rating: -65°C to +150°C.
- Maximum attenuation:
  - 0.70 dB/m at 1 GHz.
  - 1.55 dB/m at 5 GHz.
  - 2.20 dB/m at 10 GHz.
  - 3.05 dB/m at 18 GHz.
- Velocity of propagation: > 76%.
QUASI-FLEX® hand-formable semi-rigid substitute

QFX086S
AXON® part number: P540264
Cable connected to a PCB connector on one side and welded to the equipment PCB on the other side.

CONDUCTOR
- Solid conductor.
- Silver plated copper clad steel (Ag 2µm).
- Nominal diameter: 0.51 mm.

DIELECTRIC
- Extruded PTFE.
- Nominal diameter: 1.65 mm.

SHIELDING
Tin soaked silver plated copper braid (space quality defined by ECSS-Q-10-71 A).

MAIN CHARACTERISTICS
- Nominal outer diameter: 2.15 mm.
- Approximate weight: 17 g/m.
- Impedance: 50 Ω (± 2 Ω).
- Nominal capacitance: 97 pF/m.
- Temperature rating: -55°C to +125°C.
- Maximum attenuation:
  - 0.70 dB/m at 1 GHz.
  - 1.30 dB/m at 3 GHz.
  - 1.85 dB/m at 6 GHz.
  - 2.45 dB/m at 10 GHz.
  - 3.55 dB/m at 18 GHz.
- Velocity of propagation: > 69%.
AXOMACH®
panel mount connectors

Materials:
- Body: 2.5 µm gold on aluminium alloy
- Dielectric: PTFE
- Rear contact: 1.2 µm gold on copper alloy
- Mated contact: 1.2 µm gold on copper alloy

Mechanical:
- Torque screw-nut: 0.35 N.m
- Nut thickness: 1.6 mm
- Washer dimensions (e x D): 0.3 x Ø4.7 mm
- Nuts and washers are included

Single way female panel mount connector

VARIANT 01 (see details page E-23)

Two way female panel mount connector

VARIANT 02 (see details page E-23)

Four way female panel mount connector

VARIANT 03 (see details page E-24)
AXOMACH®
cable mount connectors

- Special 100 Ω insert for the transmission line
- Interfacial seal / connector to backshell interface seals: conductive silicone base rubber
- Shrinkable strain relief: fluoropolymer

Materials:
- Body: 2.5 µm gold on aluminium alloy
- Dielectric: PTFE
- Pin contact: 1.2 µm gold on copper alloy

Single way male cable mount connector

VARIANT 04 (see details page E-24)

Two way male cable mount connector

VARIANT 05 (see details page E-25)

Four way male cable mount connector

VARIANT 06 (see details page E-25)
Single way female cable mount connector

VARIANT 07 (see details page E-26)

Two way female cable mount connector

VARIANT 08 (see details page E-26)

Four way female cable mount connector

VARIANT 09 (see details page E-27)
AXOMACH®
SMD connectors

Materials:
- Body: 2.5 µm gold on aluminium alloy
- Dielectric: PTFE
- Mated contact: 1.2 µm gold on copper alloy

Single way female SMD connector

VARIANT 10 (see details page E-27)

Two way female SMD connector

VARIANT 11 (see details page E-28)

Four way female SMD connector

VARIANT 12 (see details page E-28)
Detailed AXOMACH® connector specifications

Single way female panel mount connector

**VARIANT 01**

![Diagram of Single Way Female Panel Mount Connector]

- **Dimensions:**
  - Key 5/32"
  - 2-56 UNC - 2A
  - Key 1/8"

- **Panel Cut-Out Dimensions:**
  - 6.8 ± 0.2
  - 3.8 ± 0.2
  - 5.95
  - 15

Two way female panel mount connector

**VARIANT 02**

![Diagram of Two Way Female Panel Mount Connector]

- **Dimensions:**
  - Key 5/32"
  - 2-56 UNC - 2A
  - Key 1/8"

- **Panel Cut-Out Dimensions:**
  - 6.8 ± 0.2
  - 3.8 ± 0.2
  - 5.45

Please contact us to have the whole AXOMACH® specification.
Four way female panel mount connector

**VARIANT 03**

![Diagram of Four way female panel mount connector]

Single way male cable mount connector

**VARIANT 04**

![Diagram of Single way male cable mount connector]

Please contact us to have the whole AXOMACH® specification.
Two way male cable mount connector

VARIANT 05

Four way male cable mount connector

VARIANT 06

Please contact us to have the whole AXOMACH® specification.
Single way female cable mount connector

**VARIANT 07**

Two way female cable mount connector

**VARIANT 08**

Please contact us to have the whole AXOMACH® specification.
Four way female cable mount connector

VARIANT 09

Single way female SMD connector

VARIANT 10

Please contact us to have the whole AXOMACH® specification.
Two way female SMD connector

**VARIANT 11**

![Diagram of Two Way Female SMD Connector Variant 11]

- Socket 1
- Socket 2
- Socket 3
- Socket 4

- 32mm
- 28mm
- 9mm

- Threaded hole 2-56 UNC - 2B
- Recommended tightening torque: 30cNm 0/+10%

Four way female SMD connector

**VARIANT 12**

![Diagram of Four Way Female SMD Connector Variant 12]

- Socket 1
- Socket 2
- Socket 3
- Socket 4
- Socket 5
- Socket 6
- Socket 7
- Socket 8

- 52mm
- 48mm

- 25.74mm
- 21.3mm

- 1.8mm MIN
- 2.5mm

- Threaded hole 2-56 UNC - 2B
- Recommended tightening torque: 30cNm 0/+10%

Please contact us to have the whole AXOMACH® specification.
SMA connectors (ESCC3402 QPL)

To connect AXOMACH® links to your devices equipped with SMA plugs or to create panel feedthroughs, AXON® proposes the following ESA qualified SMA connectors:

<table>
<thead>
<tr>
<th>ESCC VARIANT</th>
<th>TECHNICAL CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESCC3402/001 variant 01</td>
<td>Straight plug, solder type, for semi-rigid cable Ø 2.2 mm.</td>
</tr>
<tr>
<td>ESCC3402/001 variant 09</td>
<td>Right angle plug, solder type, for semi-rigid cable Ø 2.2 mm.</td>
</tr>
<tr>
<td>ESCC3402/002 variant 01</td>
<td>Straight jack, solder type, for semi-rigid cable Ø 2.2 mm.</td>
</tr>
<tr>
<td>ESCC3402/002 variant 09</td>
<td>Straight jack, solder type, rear mounting, 2 holes, flange mounted, for semi-rigid cable Ø 2.2 mm.</td>
</tr>
<tr>
<td>ESCC3402/002 variant 68</td>
<td>Straight jack, solder type, rear mounting, flange mounted, for semi-rigid cable Ø 2.2 mm.</td>
</tr>
<tr>
<td>ESCC3402/003 variant 07</td>
<td>Hermetic adaptor, female-female.</td>
</tr>
<tr>
<td>ESCC3402/003 variant 14</td>
<td>Straight bulkhead adaptor, female-female.</td>
</tr>
</tbody>
</table>

This list is non exhaustive.

Termination of the connectors

**AXOMACH® panel mount connectors (variants 01 to 03)**

This connector can be terminated to a PCB using flat flexible conductors in order to be mechanically decoupled between the PCB and the panel where the connector is mounted. One end of the flat conductor is soldered to the connector lead using high temperature solder or a parallel gap weld procedure. The other end is soldered on PCB tracks by using standard soldering.

This termination must be validated and approved depending on the mission environment.

**AXOMACH® cable mount connectors (variants 04 to 09) and surface mount connectors (variants 10 to 12)**

- Inner conductor is crimped to gold plated copper alloy contacts.
- Cable shield is soldered into the backshell using soft soldering.
- X-Ray inspection is performed on all link terminations.

Transmission measurements are performed on 100% of manufactured links up to 10 Gb/s. The manufacturing and control procedures are maintained in a PID followed by CNES/ESA and reviewed every two years.
Direct / indirect wiring

There are two ways to wire AXON’s AXOMACH® links: direct wiring and indirect wiring. Direct wiring being the standard way, indirect wiring is used to meet customers’ specific requirements.

The type of wiring appears in the identification code of AXOMACH® links.

AXOMACH 05 D 300 05 L3 = Direct wiring
AXOMACH 05 I 300 05 L3 = Indirect wiring

Direct wiring

```
1 2 3 4 5 6 7 8
1 2 3 4 5 6 7 8
```

Indirect wiring

```
8 7 6 5 4 3 2 1
4 3 2 1
2 1
```
**AXOMACH links®**

### IDENTIFICATION CODE

**SERIES**

**AXOMACH®**: Space High Data Rate assembly

#### CONNECTOR 1 VARIANT

- **04**: 1 way male connector
- **05**: 2 way male connector
- **06**: 4 way male connector
- **07**: 1 way female connector
- **08**: 2 way female connector
- **09**: 4 way female connector

**20**: ESCC3402 SMA connector (specify the type of SMA connector when ordering)*

#### WIRING

- **D**: Direct wiring
- **I**: Indirect wiring (see page E-30)

#### LENGTH OF CABLE

**XXX**: Length in mm
- >100 mm for 1 way: variants 04 & 07
- >200 mm for 2 ways: variants 05 & 08
- >500 mm for 4 ways: variants 06 & 09

#### CONNECTOR 2 VARIANT**

- **04**: 1 way male connector
- **05**: 2 way male connector
- **06**: 4 way male connector
- **07**: 1 way female connector
- **08**: 2 way female connector
- **09**: 4 way female connector

**20**: ESCC3402 SMA connector (specify the type of SMA connector when ordering)*

#### TESTING LEVEL**

- **L1**: LAT1 (ESCC3401-chart V)
- **L2**: LAT2 (ESCC3401-chart V)
- **L3**: LAT3 (ESCC3401-chart V)

---

*: Please refer to page E-29 for a non exhaustive list

**: If connector 2 is not specified, the assembly is a pigtail.

***: Please see page 10 of the Micro-D chapter
**AXOMACH® panel & SMD connectors**

**IDENTIFICATION CODE**  
**AXOMACH®: Space High Data Rate assembly**

**SERIES**  
**AXOMACH®: Space High Data Rate assembly**

**CONNECTOR**  
01: 1 way female PCB connector set up on panel  
02: 2 way female PCB connector set up on panel  
03: 4 way female PCB connector set up on panel  
10: 1 way female PCB connector set up on PCB, SMD mount  
11: 2 way female PCB connector set up on PCB, SMD mount  
12: 4 way female PCB connector set up on PCB, SMD mount

**TESTING LEVEL**  
L1: LAT1 (ESCC3401-chart V)  
L2: LAT2 (ESCC3401-chart V)  
L3: LAT3 (ESCC3401-chart V)

*: Please see page 10 of the Micro-D chapter
**Electrical characteristics**

Maximum rating for a 1 metre link terminated with two single way cable mount connectors.

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic impedance (Zc)</td>
<td>90 Ω &lt; Zc &lt; 100 Ω</td>
</tr>
<tr>
<td>Jitter τ (at 1, 3, 5, 6, 8 and 10 Gb/s)</td>
<td>Maximum 20 ps</td>
</tr>
<tr>
<td>Jitter τ (at 1, 3, 5, 6, 8 and 10 Gb/s)</td>
<td>Maximum 5 ps</td>
</tr>
<tr>
<td>Quality factor (Qf)</td>
<td>At 1 Gb/s</td>
</tr>
<tr>
<td></td>
<td>At 3 Gb/s</td>
</tr>
<tr>
<td></td>
<td>At 5,6,8 and 10 Gb/s</td>
</tr>
<tr>
<td>Skew (Sk) between coaxial cables</td>
<td>Maximum 20 ps</td>
</tr>
<tr>
<td>Insertion Loss (IL)</td>
<td>0 to 5 GHz</td>
</tr>
<tr>
<td></td>
<td>0 to 10 GHz</td>
</tr>
<tr>
<td>Return Loss (RL)</td>
<td>0 to 5 GHz</td>
</tr>
<tr>
<td></td>
<td>0 to 10 GHz</td>
</tr>
<tr>
<td>Crosstalk far end (XTF - 0 to 5 GHz)</td>
<td>Maximum -45 dB</td>
</tr>
<tr>
<td>Crosstalk near end (XTN - 0 to 10 GHz)</td>
<td>Maximum -35 dB</td>
</tr>
<tr>
<td>Time analysis (jitter and quality factor) at room temperature</td>
<td>See table below</td>
</tr>
</tbody>
</table>

**EMC: AXOMACH link shielding efficiency**

(From 500 MHz to 18 GHz)

![Shielding efficiency graph](image)

Shielding effectiveness for a 1 metre link < -60 dB up to 10 GHz

**Time analysis (jitter & quality factor) at room temperature for a 1 metre link with 0.2 m test jig**

<table>
<thead>
<tr>
<th>DATA RATE</th>
<th>1 GHz</th>
<th>3 GHz</th>
<th>5 GHz</th>
<th>6 GHz</th>
<th>8 GHz</th>
<th>10 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jitter τ</td>
<td>&lt; 20 ps</td>
<td>&lt; 20 ps</td>
<td>&lt; 20 ps</td>
<td>&lt; 20 ps</td>
<td>&lt; 20 ps</td>
<td>&lt; 20 ps</td>
</tr>
<tr>
<td>Jitter τ</td>
<td>&lt; 5 ps</td>
<td>&lt; 5 ps</td>
<td>&lt; 5 ps</td>
<td>&lt; 5 ps</td>
<td>&lt; 5 ps</td>
<td>&lt; 5 ps</td>
</tr>
<tr>
<td>Quality factor</td>
<td>&gt; 20</td>
<td>&gt; 15</td>
<td>&gt; 10</td>
<td>&gt; 10</td>
<td>&gt; 10</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>Eye pattern</td>
<td><img src="image" alt="Eye pattern image" /></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

More information available on request.

Generator output signal: 2^31-1 PRBS pattern with 1Vpp differential amplitude.
# Mechanical characteristics

### Characteristics

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum cable weight</td>
<td>15 g/m per cable</td>
</tr>
<tr>
<td></td>
<td>30 g/m per way</td>
</tr>
<tr>
<td>Mating force</td>
<td>&lt; 5.6 N (2.8 N per contact)</td>
</tr>
<tr>
<td>Demating force</td>
<td>1 N &lt; demating force &lt; 5.6 N</td>
</tr>
<tr>
<td>Operating and storage temperature</td>
<td>-55°C to +125°C</td>
</tr>
<tr>
<td>Total Mass Loss (TML)</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Collected Volatile Condensable Material (CVCM)</td>
<td>&lt; 0.1 %</td>
</tr>
<tr>
<td>Recovered Mass Loss (RML)</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

### Variant Nom. Connector Weight (g)

<table>
<thead>
<tr>
<th>VARIANT</th>
<th>NOM. CONNECTOR WEIGHT (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PCB / panel mount connectors</td>
</tr>
<tr>
<td></td>
<td>Male cable mount connectors</td>
</tr>
<tr>
<td></td>
<td>Female cable mount connectors</td>
</tr>
<tr>
<td></td>
<td>PCB surface mount connectors</td>
</tr>
<tr>
<td>01</td>
<td>3 g</td>
</tr>
<tr>
<td>02</td>
<td>4 g</td>
</tr>
<tr>
<td>03</td>
<td>5 g</td>
</tr>
<tr>
<td>04</td>
<td>13 g* / 5 g without cable</td>
</tr>
<tr>
<td>05</td>
<td>23 g* / 7 g without cable</td>
</tr>
<tr>
<td>06</td>
<td>47 g* / 15 g without cable</td>
</tr>
<tr>
<td>07</td>
<td>14 g* / 6 g without cable</td>
</tr>
<tr>
<td>08</td>
<td>24 g* / 8 g without cable</td>
</tr>
<tr>
<td>09</td>
<td>49 g* / 16 g without cable</td>
</tr>
<tr>
<td>10</td>
<td>5 g</td>
</tr>
<tr>
<td>11</td>
<td>8 g</td>
</tr>
<tr>
<td>12</td>
<td>14 g</td>
</tr>
</tbody>
</table>

*: Value specified for a ax2.4S cable length of 300 mm

### Manufacturing

AXOMACH® components are manufactured and tested in clean room conditions. Cleanliness level: Class ISO 8 = Class 100 000 following FED STD 209E.

AXON® operators are certified by international space agencies on soldering and crimping process according to ECSS-Q-ST-70-08 & ECSS-Q-ST-70-26.

AXON® is monitored by CNES (French space agency) for AXOMACH® connectors and links manufacturing and controlled according to PID (Know How agreement in progress).
Qualification

Environmental, mechanical and endurance testing are performed according to ESCC3401 chart IV.

- 16 Mated Connector Sets (1)
- 70 Contact Sets (1)

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring Para. 9.10</td>
<td>Wiring Para. 9.10</td>
<td>Wiring Para. 9.10</td>
<td>Wiring Para. 9.10</td>
</tr>
<tr>
<td>Shock or Bump Para. 9.12</td>
<td></td>
<td>High Temp. Storage Para. 9.21</td>
<td>Overload Test Para. 9.26</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>Climatic Sequence Para. 9.13</td>
<td>Contact Retention Para. 9.17</td>
<td>Corrosion Para. 9.22</td>
<td>Maintenance Aging (4) Para. 9.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seal Test Para. 9.9</td>
<td>Permanence of Marking Para. 9.19</td>
<td>Insert Retention Para. 9.23</td>
<td>Joint Strength (5) Para. 9.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plating Thickness (3) Para. 9.14</td>
<td>Seal Test Para. 9.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint Strength (5) Para. 9.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 Contact Sets (2)</td>
<td>35 Contact Sets (6)</td>
</tr>
<tr>
<td>Engage/Sep. Forces Para. 9.28</td>
<td>Solderability Para. 9.31</td>
</tr>
<tr>
<td>Oversize Pin Exclusion Para. 9.29</td>
<td></td>
</tr>
<tr>
<td>Probe Damage Para. 9.30</td>
<td></td>
</tr>
<tr>
<td>Plating Thickness Para. 9.14</td>
<td></td>
</tr>
</tbody>
</table>

1 1
### Table of weights

#### High speed links
SpaceWire & IEEE 1394.

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>WEIGHT (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cables</strong></td>
<td></td>
</tr>
<tr>
<td>28AWG SpaceWire</td>
<td>85 g/m maximum</td>
</tr>
<tr>
<td>26AWG SpaceWire</td>
<td>115 g/m maximum</td>
</tr>
<tr>
<td>IEEE 1394</td>
<td>84 g/m maximum</td>
</tr>
<tr>
<td><strong>Connectors</strong></td>
<td></td>
</tr>
<tr>
<td>9 way male connector</td>
<td>about 8 g</td>
</tr>
<tr>
<td>(with screwlock and</td>
<td></td>
</tr>
<tr>
<td>backshell)</td>
<td></td>
</tr>
<tr>
<td>9 way female connector</td>
<td>about 8 g</td>
</tr>
<tr>
<td>(with screwlock and</td>
<td></td>
</tr>
<tr>
<td>backshell)</td>
<td></td>
</tr>
<tr>
<td>9 way female CBR</td>
<td>about 3 g</td>
</tr>
<tr>
<td>connector</td>
<td></td>
</tr>
</tbody>
</table>

#### Low Mass solutions

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>WEIGHT (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cables</strong></td>
<td></td>
</tr>
<tr>
<td>Low Mass 28AWG SpaceWire</td>
<td>42 g/m maximum</td>
</tr>
<tr>
<td>Ultra Low Mass Coax cable (with overall shield)</td>
<td>32.5 g/m maximum</td>
</tr>
<tr>
<td>Ultra Low Mass Coax cable (without overall shield)</td>
<td>30 g/m maximum</td>
</tr>
<tr>
<td><strong>Connectors</strong></td>
<td></td>
</tr>
<tr>
<td>Micro-D connector</td>
<td>about 8 g</td>
</tr>
<tr>
<td>(with screwlock and</td>
<td></td>
</tr>
<tr>
<td>backshell)</td>
<td></td>
</tr>
<tr>
<td>Nano-D connector</td>
<td>about 2 g</td>
</tr>
<tr>
<td>(with screwlock and</td>
<td></td>
</tr>
<tr>
<td>backshell)</td>
<td></td>
</tr>
</tbody>
</table>
### AXOMACH® Links

<table>
<thead>
<tr>
<th>AXON® REFERENCES</th>
<th>WEIGHT (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cables</strong></td>
<td></td>
</tr>
<tr>
<td>AXOWAVE 2.4</td>
<td>12 g/m (24 g/m per way)</td>
</tr>
<tr>
<td>(Microwave coaxial cable)</td>
<td></td>
</tr>
<tr>
<td>QFX086S</td>
<td>17 g/m (34 g/m per way)</td>
</tr>
<tr>
<td>(QUASIFLEX hand-formable semi-rigid substitute)</td>
<td></td>
</tr>
<tr>
<td><strong>PCB / panel mount connectors</strong></td>
<td></td>
</tr>
<tr>
<td>Variant 01</td>
<td>3 g</td>
</tr>
<tr>
<td>Variant 02</td>
<td>4 g</td>
</tr>
<tr>
<td>Variant 03</td>
<td>5 g</td>
</tr>
<tr>
<td><strong>Male cable mount connectors</strong></td>
<td></td>
</tr>
<tr>
<td>Variant 04</td>
<td>5 g</td>
</tr>
<tr>
<td>Variant 05</td>
<td>7 g</td>
</tr>
<tr>
<td>Variant 06</td>
<td>15 g</td>
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<tr>
<td><strong>Female cable mount connectors</strong></td>
<td></td>
</tr>
<tr>
<td>Variant 07</td>
<td>6 g</td>
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<tr>
<td>Variant 08</td>
<td>8 g</td>
</tr>
<tr>
<td>Variant 09</td>
<td>16 g</td>
</tr>
<tr>
<td><strong>PCB surface mount connectors</strong></td>
<td></td>
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<td>Variant 10</td>
<td>5 g</td>
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<td>Variant 11</td>
<td>8 g</td>
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<tr>
<td>Variant 12</td>
<td>14 g</td>
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